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Robert J. Kauffman
University of Minnesota

Yu-Ming Wang
Syracuse University

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Robert J. Kauffman, Carlson School of Management, University of Minnesota
Yu-Ming Wang, School of Management, Syracuse University

Introduction

Many industries whose products and services are based on information technology are being swept by asset buyouts, mergers and consolidations, a trend that promises to bring increased competition and cooperation, and lower prices for consumers. We have seen this happen in the world of packaged software products, including database management products, CASE tools, LAN software and software suites. The recent news of the merger of IBM and Lotus, and Microsoft's attempted purchase of Intuit are cases in point. In a similar vein, the cellular communications industry already has experienced a number of consolidations, with the result that the big players have gotten dramatically bigger.

The market for services delivered by retail electronic payment networks also has experienced a deal of change in the last decade. Electronic banking networks have been merging with and acquiring one another in their fight for market share. The result is that the average network has increased in size, and although automated teller machine (**ATM**) usage has expanded even more dramatically, today fewer and fewer electronic banking networks exist (O'Keefe, 1994). Each of these industry scenarios shares an important feature: installed base appears to give rise to *network externalities* that create value for users who adopt common solutions and buy into shared technological standards. This, in turn, creates value for the acquirers or for the owners of the merged network.

Why do some network technologies consolidate with competing technologies or networks to remain competitive, while others evolve to become dominant? How can these outcomes be explained? Although much has been written on the adoption of technologies and networks in the presence of beneficial externalities by economists (e.g., Farrell and Saloner, 1985; Katz and Shapiro, 1985; Oren and Smith, 1981) and IS researchers (e.g., Bakos, 1991; Chismar and Meier, 1992; Clemons and Kleindorfer, 1992; Gurbaxani and Whang, 1991; Seidmann and Wang, 1994), little is known about why network mergers occur under these circumstances. This research examines the determinants of *network default* (when a network goes out of business by its own choice) and *network consolidation* in electronic banking networks, and suggests a general evaluative framework that applies more broadly, to a spectrum of information technologies and competitive interorganization information systems that offer network externalities.

The Hazard Modeling Approach

Our research approach involves "hazard modeling", developed by social scientists interested in predicting such phenomena as the efficacy of alternative cancer treatments, the lifespans of cigarette smokers, the duration of unemployment for skilled workers, and financial distress and corporate bankruptcy. Hazard models (also known as "duration" or "failure time" models in the economics literature) have also been used to study the diffusion of a variety of technological innovations (e.g., Hannan and McDowell, 1984; Levin, Levin, and Meisel, 1987; Rose and Joskow, 1990). This approach enables the researcher to model the effects of explanatory variables on the occurrence of an event (e.g., corporate bankruptcy), or, alteratively, the duration of time that passes prior to an event (e.g., months of life prior to death from cancer).

Using this approach, we will empirically assess the impact of explanatory variables such as network installed base, transaction and revenue flows, network governance and cost structure, and market structure variables on the probability of electronic banking network default or consolidation. This is called a *hazard function*, and *its estimation provides information on the conditional likelihood of a regressor leading to some event*.

We identify two kinds of events to be modeled that yield somewhat different operational definitions for *duration*:

(1) When a network goes out of business, duration is the elapsed time in our study sample period until default occurs.

(2) When a network merges with another network, duration measures the elapsed time in the sample period until the merger.

These definitions enable us to construct and estimate two separate hazard models: one will explain electronic banking network defaults and the other will explain network mergers.

Estimation of hazard models requires care in dealing with three separate issues. *First*, some explanatory variables vary over time (e.g., incumbent and competitor network installed bases, transaction and revenue flows, etc.) while others remain fixed (e.g., network governance structure, market structure, etc.). This creates a challenge in data collection, because such time-varying covariates are often difficult to capture during the period of interest. Related to this is the need to use econometrics routines that can handle variables that vary over time. Most packages that estimate hazard functions do not allow for time-varying covariates. *Second,* observations of network default or consolidation times are *right-censored*: not all networks default or merge by the end of the study period, and continue to operate as they did in the past. Thus, the estimation model must accommodate censoring. However, techniques to accomplish this are readily available with econometrics software that can estimate hazard functions.

Third, it is important to understand that the econometric results involve maximum likelihood estimates (**MLE**) of the probability of the occurrence of the event, conditional on a unit change in an explanatory variable. The method does not produce t-statistics or R-squares, as do OLS or GLS regression. The MLE techniques that we will apply enable us to incorporate time-varying covariates and heterogeneous decisions by networks to default or consolidate. Additional useful methodological background can be found in Kalbfleisch and Prentice (1980), Kiefer (1988) and Peterson (1991).

Research Context and Data

We will report results on competition among regional shared electronic banking networks between 1982 and 1994. Sharing ATMs among banking firms became widely accepted in the early 1980s, because shared networks offered customers greater access to their bank accounts and gave network member banks an opportunity to earn interchange revenues when their ATMs are used by other member banks' customers, while taking advantage of network economies of scale. In late 1982, there were 175 shared networks operating in various regions of the U.S. market. Since that time, however, we have seen extensive network consolidation in the marketplace. Today there are fewer than 85 shared networks still operating, as the industry pushes to serve its customers with network operations involving more extensive geographic coverage, larger scale size, different ownership arrangements, and lower operating costs.

Our data set captures information about all regional shared electronic banking networks that have existed in the U.S. since 1982. The data were obtained entirely from secondary sources, including banking and payments industry newspapers, magazines and newsletters, supplemented with additional information available from published studies and Federal Reserve Bank sources. The data set includes information on network default and consolidation dates (the dependent variable for each of the models) and explanatory variables such as network transactions and revenues, installed base, ownership and cost structure, and market specific variables. We are in the process of collecting additional data to enrich the explanatory capability of our models.

Expected Contributions

This study is intended to provide one of the first systematic analyses of defaults and mergers in a setting involving network externalities. Based on prior experience that we have had with hazard modeling in other research contexts, we can reasonably expect to be able to identify the relative importance of the determinants of network mergers. We also expect to be able to develop a profile of those networks that are likely to default or grow. The results of this study also will provide managerial implications for other telecommunications network contexts, such as commercial on-line computer networks and wireless or cellular communications, as well as for many non-networked information technology products and applications that have the characteristics of networks. The latter includes technologies with evolving standards, including object-oriented software development tools, as well as software products that have an existing installed base, such as local and wide area telecommunication.

Although we recognize as this research progresses the limitations inherent in selecting one technology and one industry setting, we nevertheless intend, as a by-product of this empirical research, to propose a more general framework for analysis to represent the essence of network merger and acquisition decisionmaking in the presence of externalities.

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